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LOW-COST SMALL SPACECRAFT TO EXPLORE THE EDGE OF THE SOLAR SYSTEM

Abstract

The Voyager Interstellar Mission is providing unique scientific returns decades after the spacecraft completed the primary mission. In the future, New Horizons will join in exploring the outer limits of the Solar System. The primary missions for these spacecraft were focused on planetary exploration and their interstellar missions can be viewed as missions of opportunity enabled by unique orbital trajectories. The spacecraft were designed to fulfill their primary missions and their instruments and capabilities far exceed the requirements of their interstellar missions.

Exploration requirements at the edge of the Solar System are modest compared to planetary fly-bys and do not require fast data collection or high data-rate sensors such as imagers. Dedicated Interstellar missions could be accomplished by small spacecraft with low-data sensors to measure space environments (magnetic fields, solar wind, plasma flows, etc.). The resulting spacecraft require little power and minimal data rates. However, dedicated missions to the edge of the Solar System can only be justified at low cost and traditional deep space systems are very expensive. However, recent advances in small, low-cost satellite technology are changing the performance to cost ratio of scientific missions in LEO and beyond. Utilizing these new technologies can provide the basis for affordable dedicated deep-space missions. Specific relevant technologies include:

Advanced Low-Power Electronics: The latest generation of nano-satellite avionics can operate with consumptions of a few watts and have stand-by modes well below one watt. Initially, these COTS systems were vulnerable to radiation damage, but new rad tolerant systems are being developed.

Advanced Miniaturized Deployables: Missions like Nanosail-D and Lightsail have demonstrated the capability to deploy very large apertures (beyond 30m2) from small 3U CubeSats.

This paper analyzes the feasibility of low-cost, solar-powered deep space missions enabled by these technologies. The proposed design incorporates a large solar concentrator illuminating a small spacecraft with nanosatellite-based avionics and instruments. Even at 100AU a 30m2 area would collect over 4W of Solar energy, sufficient for the mission, eliminating the need for expensive RTGs. The concentrator can also serve as a high-gain antenna reducing communication power requirements. The paper also explores trajectory options to reach the edge of the Solar Systems including direct launch, using low-cost Nano-Launchers, and secondary payload rides on outer planets missions. The results indicate that advances in small satellite technologies will make dedicated low-cost missions to the edge of the Solar System feasible in the very near future.